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A NOVEL METHOD TO MEASURE THE MICROMOTION OF ACETABULAR CUP AFTER TOTAL HIP REPLACEMENT

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Research Summary

The amount of initial stability is an important factor in determining the level of osseointegration press-fit cups will achieve. Most methods used to assess cup stability do not reproduce physiological loading conditions and use simplified spherical cavity models. The aim of this study was to determine whether using spherical cavities over-estimates the stability of the cup compared to a more anatomical, but still simplified model of the acetabulum. A secondary aim was to assess a novel method for measuring the micromotion of the cup.

A press-fit cup was inserted into Sawbones foam blocks with two different cavity geometries: a spherical one and a more physiological one. The stability of the cup was assessed in two ways: a novel method of measuring the micromotion of the cup under physiological loading, and a uniaxial push-out test.

The results indicate that the micromotion was greater with the more physiological acetabular model. The push-out force is greater for the spherical model. Considering these results, it may be considered that acetabular models with a spherical cavity over-estimate the initial stability of the press-fit cup. These initial results also demonstrate the reliability of the novel method used to measure the micromotion of the cup under physiological loading.

Introduction

Initial stability is an important prerequisite for press-fit acetabular cups. A poorly fixed cup is prone to micromotion under physiological loading. If micromotion is above 150 µm osseointegration is inhibited [1], resulting in implant loosening.

Most methods used to assess the stability of cups are static, load-to-failure tests, which do not replicate *in vivo* conditions. Furthermore, they use foam models with a spherical cavity, which do not take into account the structural properties associated with the posterior and anterior columns of the acetabulum.

Hypothesis

The aim of this study was to demonstrate that using simplified hemispherical cavities as an acetabular model over-estimates the stability of press-fit cups.

Methods

A press-fit cup (Trident, Stryker) was inserted into six reamed polyurethane foam blocks (Sawbones; density=0.48 g/cm³). Two acetabular cavity geometries were investigated: the first one was a spherical cavity and the second a more physiological geometry. The more physiological geometry modelled the pinching effect of the acetabular columns and the non-supportive areas of the acetabular notch and the radiolucent triangle (Fig. 1).

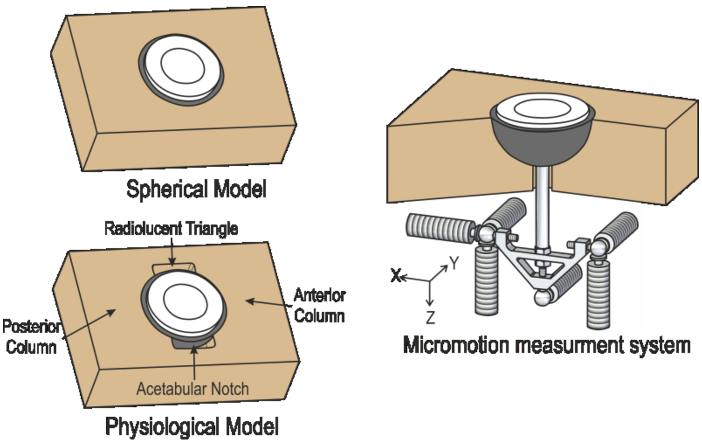

Fig. 1 – System to measure the micromotion of the cup in six degrees of freedom and the two different acetabular geometries tested.

Two methods were used to assess the primary stability of the cup. The first in six degrees of freedom when loaded under physiological conditions at 30° from the horizontal (1 Hz, 1000 cycles, 2.0 kN peak load) (Fig. 1). The second method measured the peak failure load during uniaxial push-out following the cyclic loading.

For statistical analysis, Wilcoxon signed ranks tests with a type I error probability of $\alpha=0.05$ were performed.

Results

The micromotion was always greater for the physiological geometry compared to the spherical geometry. There was also a change in the relative direction of the micromotion: the motion in the Z direction became greater than the motion in the Y direction when the cup was implanted in the physiological cavity compared to the spherical cavity (Fig. 2).

The peak push-out force was significantly greater in the spherical geometry than in the more physiological one (1.46 ± 0.07 kN vs. 0.96 ± 0.03 kN respectively).

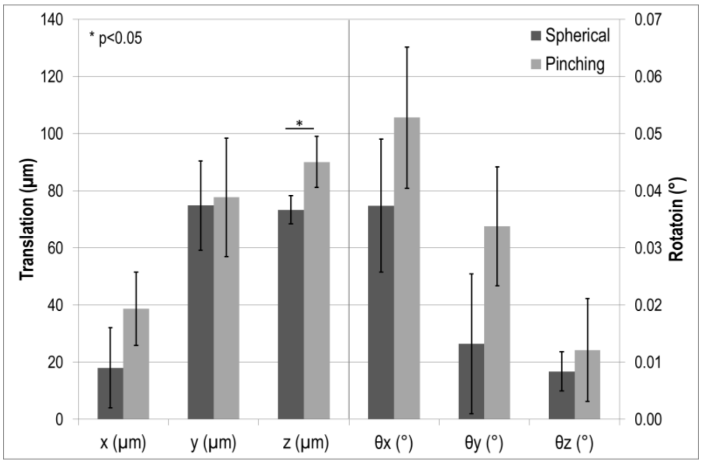

Fig. 2 – Micromotion in six degrees of freedom of the cup for the two different acetabular geometries under cyclic loading and orientated 30° from the horizontal (1 Hz, 1000 cycles, 2.0 kN peak force).

Discussion and Conclusion

The micromotions measured during cyclic loading are below 150 µm and are similar to published values from cadaveric studies [2]. The push-out forces are similar to published pull-out forces [3].

Differences in micromotion and in push-out forces show that acetabular geometry has an important effect on cup stability. As the more physiological model was validated in a previous study using cadaveric pelves [4], the results obtained with this model are most likely the more physiological ones. Therefore, it may be considered that the spherical geometry over-estimates the stability of press-fit cups.

Significance

The novel measurement method used in this study, combined with a more physiological acetabular model, provides an insight into how a cup behaves *in vivo*. With further development, it could become a key method for pre-clinical testing.

Key References

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[2] Kwong *et al.*, 1994, *J Arthroplasty*, 9
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